# Responses to Short Comments

## Effects of Arctic stratospheric ozone changes on spring precipitation in the northwestern United States (ACP-2018-414)

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*You decrease/increase the ozone climatology homogeneously by 15% in R2/R3, which will also amplify zonal inhomogeneity in the ozone climatology because already greater ozone mixing ratios will be increased more in terms of absolute magnitude. Several studies (e.g. Gabriel et al. 2007, Gillet et al. 2009, McCormack et al. 2011, Nowack et al. 2018) showed that such zonal asymmetry can be important for the Arctic vortex climatology and as a result surface climate. Do you have any means of determining the importance of the general increase/decrease in ozone imposed by you as compared to the amplification of the zonal structure, which might be particularly important for the vortex climatology? It would be great if you could put your results into context.*

**Response: We thank the reviewer for the positive evaluation of our study and sincerely appreciate the reviewer's insightful and helpful comments. We are also sorry for missing some important references in the manuscript. The following references had been added in the revised manuscript (*Gabriel et al., 2007; Gillett et al., 2009; Nowack et al., 2015, 2017, 2018; McCormack et al., 2011*).**

**The experiments preformed in this study are in order to confirm that whether the observed positive/negative ASO anomalies could force the abnormal precipitation in the northwestern United States. Fig. R1a and b show the observed ozone anomalies during negative and positive ASO anomalies events, respectively. Fig. R1c and d show the negative ozone forcing in R2 and positive ozone forcing in R3, respectively. Fig. R1 illustrates that the ozone forcings imposed in R2/R3 is similar to the observations, indicating the ozone forcings given in the experiments are reasonable. The results in our manuscript show that this kind of ozone forcing indeed could cause the observed precipitation anomalies in the northwestern United States.**

**The question, i.e., "*general increase/decrease in ozone or the amplification of zonal structure of ozone, which might be particularly important for the vortex climatology*" is a very important question; however, we think it isn't the focus of this article. This issue needs a further proof and a lot of experiments to demonstrate. If we put these contents in the text, it will make the manuscript too**

**long and too complicated. This point is a good idea, and we will try to finish it in the next work.**

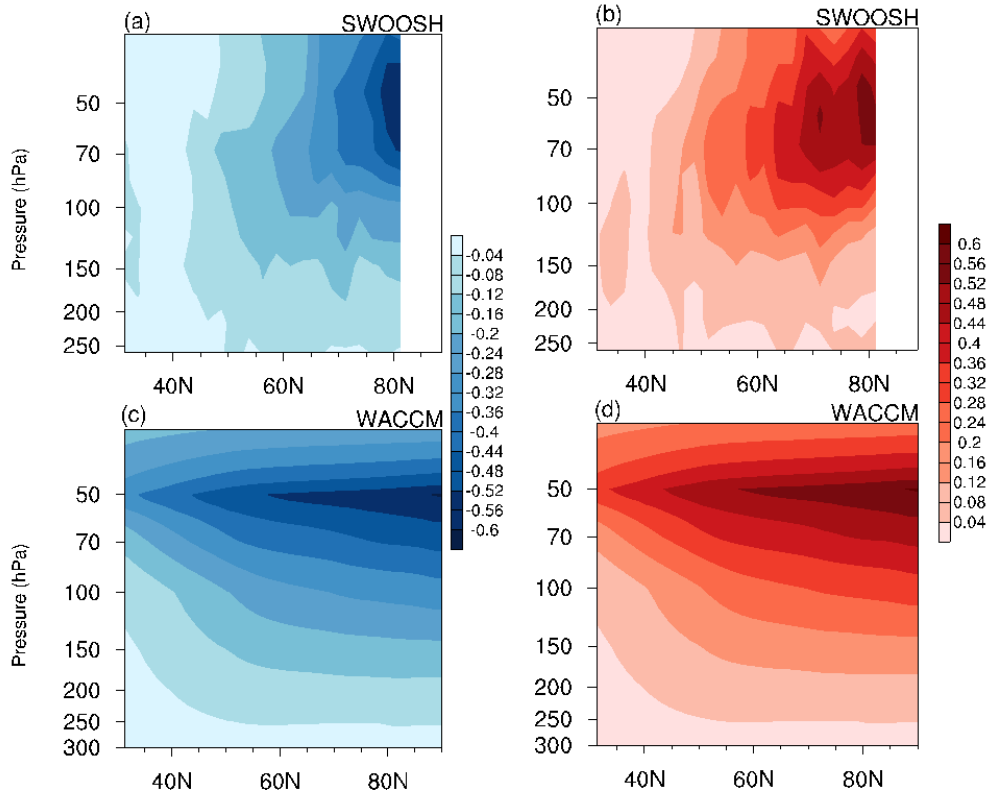


**Figure R1. The composite ozone anomalies (ppmv) during negative (a) and positive (b) ASO anomalies events, based on SWOOSH ozone data from 1984 to 2016. The definition of ASO anomalies events please refers to manuscript. The negative ozone forcing in R2 (c) and positive ozone forcing in R3 (d) in WACCM4 experiments, respectively.**

## References:

*Gabriel, A., Peters, D., Kirchner, I. & Graf, H. F. (2007), 'Effect of zonally asymmetric ozone on stratospheric temperature and planetary wave propagation', Geophysical Research Letters 34(6).*

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*Nowack, P. J., Abraham, N. L., Braesicke, P. & Pyle, J. A. (2018), 'The impact of stratospheric ozone feedbacks on climate sensitivity estimates', Journal of Geophysical Research: Atmospheres 123, 4630-4641.*

*Nowack, P.J., Braesicke, P., Abraham, N. L. & Pyle, J. A. (2017), 'On the role of ozone feedback in the ENSO amplitude response under global warming', Geophysical Research Letters 44, 3858–3866.*

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*Osprey, A. & Pyle, J. A. (2015). A large ozone-circulation feedback and its implications for global warming assessments. Nature climate change, 5, 41-45.*

*McCormack, J. P., Nathan, T. R. & Cordero, E. C. (2011), 'The effect of zonally asymmetric ozone heating on the Northern Hemisphere winter polar stratosphere', Geophysical Research Letters 38(3), 1–5.*